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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	MI 22-1243
First Inventor or Application Identifier	Juengling
Title	Semiconductor Processing Methods of...
Express Mail Label No.	E 3733A2021

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

<p>1. <input checked="" type="checkbox"/> * Fee Transmittal Form (e.g., PTO/SB/17) (Submit an original, and a duplicate for fee processing)</p> <p>2. <input checked="" type="checkbox"/> Specification [Total Pages 34] (preferred arrangement set forth below) (plus title pg.)</p> <ul style="list-style-type: none"> - Descriptive title of the Invention - Cross References to Related Applications - Statement Regarding Fed sponsored R & D - Reference to Microfiche Appendix - Background of the Invention - Brief Summary of the Invention - Brief Description of the Drawings (if filed) - Detailed Description - Claim(s) - Abstract of the Disclosure <p>3. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets 12]</p> <p>4. Oath or Declaration [Total Pages 3]</p> <ul style="list-style-type: none"> a. <input type="checkbox"/> Newly executed (original or copy) b. <input checked="" type="checkbox"/> Copy from a prior application (37 C.F.R. § 1.63(d)) (for continuation/divisional with Box 17 completed) [Note Box 5 below] <p>i. <input type="checkbox"/> DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. §§ 1.63(d)(2) and 1.33(b).</p> <p>5. <input checked="" type="checkbox"/> Incorporation By Reference (useable if Box 4b is checked) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered to be part of the disclosure of the accompanying application and is hereby incorporated by reference therein.</p>	<p>6. <input type="checkbox"/> Microfiche Computer Program (Appendix)</p> <p>7. Nucleotide and/or Amino Acid Sequence Submission (if applicable, all necessary)</p> <ul style="list-style-type: none"> a. <input type="checkbox"/> Computer Readable Copy b. <input type="checkbox"/> Paper Copy (identical to computer copy) c. <input type="checkbox"/> Statement verifying identity of above copies
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ACCOMPANYING APPLICATION PARTS

<p>8. <input type="checkbox"/> Assignment Papers (cover sheet & document(s))</p> <p>9. <input type="checkbox"/> 37 C.F.R. §3.73(b) Statement (when there is an assignee) <input type="checkbox"/> Power of Attorney</p> <p>10. <input type="checkbox"/> English Translation Document (if applicable)</p> <p>11. <input checked="" type="checkbox"/> Information Disclosure Statement (IDS)/PTO-1449 <input type="checkbox"/> Copies of IDS Citations</p> <p>12. <input checked="" type="checkbox"/> Preliminary Amendment</p> <p>13. <input checked="" type="checkbox"/> Return Receipt Postcard (MPEP 503) (Should be specifically itemized)</p> <p>* Small Entity Statement(s) <input type="checkbox"/> Statement filed in prior application (PTO/SB/09-12) <input type="checkbox"/> Status still proper and desired</p> <p>14. <input type="checkbox"/> Certified Copy of Priority Document(s) (if foreign priority is claimed)</p> <p>15. <input type="checkbox"/> Other: Check #124225.....</p>	<p>.....</p> <p>* A new statement is required to be entitled to pay small entity fees, except where one has been filed in a prior application and is being relied upon.</p>
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17. If a CONTINUING APPLICATION check appropriate box, and supply the requisite information below and in a preliminary amendment:

Continuation Divisional Continuation-in-part (CIP) of prior application No. 09,036,701

Prior application information: Examiner Tsai Group / Art Unit: 2812

18. CORRESPONDENCE ADDRESS

<input checked="" type="checkbox"/> Customer Number or Bar Code Label		021567	or <input type="checkbox"/> Correspondence address below <i>(Insert Customer No. or Attach bar code label here)</i>	
Name	David G. Latwesen, Ph.D.			
	WELLS, ST. JOHN, ROBERTS, GREGORY & MATKIN, P.S.			
Address	601 W. First Avenue, Suite 1300			
City	Spokane	State	WA	Zip Code
Country	USA	Telephone	(509) 624-4276	Fax

Name (Print/Type)	David G. Latwesen, Ph.D.	Registration No. (Attorney/Agent)	38,533
Signature		Date	10/21/99

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EL 37304 2021

1 **IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

2

priority Application Serial No. 09/036,701
3

priority Filing Date March 6, 1998
3 Inventor Werner Juengling
4 Assignee Micron Technology, Inc.
4

priority Group Art Unit 2812
5

priority Examiner H. Tsai
5 Attorney's Docket No. MI22-1243
6 Title: Semiconductor Processing Methods of Forming Devices on a Substrate,
6 Forming Device Arrays on a Substrate, Forming Conductive Lines on a
6 Substrate, and Forming Capacitor Arrays on a Substrate, and Integrated
7 Circuitry

8

9 **PRELIMINARY AMENDMENT**

10 To: **BOX PATENT APPLICATION**
11 Assistant Commissioner for Patents
11 Washington, D.C. 20231

12 From: David G. Latwesen (Tel. 509-624-4276; Fax 509-838-3424)
13 Wells, St. John, Roberts, Gregory & Matkin P.S.
13 601 W. First Avenue, Suite 1300
14 Spokane, WA 99201-3828

15

16 **AMENDMENTS**

17 **In the Specification**

18 At p. 1 before the "Technical Field" section, please insert the
19 following:

20 **--RELATED PATENT DATA**

21 This patent resulted from a divisional application of U.S. Patent
22 Application Serial No. 09/036,701, filed March 6, 1998, which is a

1 divisional application of U.S. Patent Application Serial No. 08/742,895,
2 filed November 1, 1996...
3

4 **In the Claims:**

5 Cancel claims 1-50.
6

7 **New Claims**

8 51. A method of forming a plurality of DRAM capacitors
9 comprising:

10 etching capacitor container openings for an array in a substrate in
11 at least two separate etching steps, and forming electrically insulative
12 partitions between adjacent capacitors intermediate the two etching steps.

13
14 52. The method of claim 51 wherein the forming electrically
15 insulative partitions step comprises:

16 forming insulative material over the substrate; and
17 conducting an anisotropic etch of the insulative material to a
18 degree sufficient to leave the partitions.

19
20 53. A processing method of forming a plurality of DRAM
21 capacitors comprising etching capacitor container openings for a capacitor
22 array in a substrate in two separate etching steps.

1 **REMARKS**

2 Claims 1-50 are canceled and new claims 51-53 are added. Claims
3 51-53 correspond to claims 56-58 of the parent application, which an
4 Examiner of the parent application indicated pertain to a distinct species
5 relative to other claims of the priority application. Applicant requests
6 examination of claims 51-53.

7
8 Respectfully submitted,

9 Dated: 10/21/99

10 By: David G. Latwesen
11 David G. Latwesen, Ph.D.
12 Reg. No. 38,533

EL373342021

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR LETTERS PATENT

* * * *

Semiconductor Processing Methods Of Forming
Devices On A Substrate, Forming Device Arrays
On A Substrate, Forming Conductive Lines On A
Substrate, And Forming Capacitor Arrays On A
Substrate, And Integrated Circuitry

* * * *

INVENTOR

Werner Juengling

ATTORNEY'S DOCKET NO. MI22-483

EM156306369

EMC57275166

1 TECHNICAL FIELD

2 This invention relates to semiconductor processing methods of
3 forming devices on or over a substrate, forming device arrays on or
4 over a substrate, forming conductive lines on or over a substrate, and
5 forming capacitor arrays on or over a substrate. The invention also
6 relates to semiconductor device arrays, and in particular to series of
7 conductive lines and capacitor arrays.

8

9 BACKGROUND OF THE INVENTION

10 Circuit devices which are fabricated on or over semiconductor
11 wafers typically undergo one or more photolithographic steps during
12 formation. During such photolithographic steps, device features can be
13 etched using conventional techniques. The spacing between such devices
14 is important because often times adjacent devices must be electrically
15 isolated from one another to avoid undesirable shorting conditions.

16 One of the limitations on device spacing stems from limitations
17 inherent in the photolithographic process itself. In the prior art,
18 devices are generally spaced only as close as the photolithographic limit
19 will permit.

20 By way of example and referring to Figs. 1 and 2, a
21 semiconductor wafer fragment is indicated generally by reference
22 numeral 25. Fragment 25 includes a substrate 29 atop which a
23 material 28 is provided. A plurality of patterned masking layers 26 are
24 formed atop material 28.

Referring to Fig. 3, material 28 is anisotropically etched to form lines 30 atop substrate 29. As shown, individual lines have respective widths L_1 which constitute the minimum photolithographic feature size available for a line. Typically, a separation S_1 separates adjacent lines across the substrate as shown. Such dimension is typically only slightly larger than L_1 but could be the same as L_1 . The term "pitch" as used in this document is intended to be in its conventional usage, and is defined as the distance between one edge of a device and the corresponding same edge of the next adjacent device. Accordingly and in the illustrated example, the pitch between adjacent lines P_1 (i.e., from the left illustrated edge of one line to the left illustrated edge of the next immediately adjacent line) is equal to the sum of L_1 and S_1 .

As integrated circuitry gets smaller and denser, the need to reduce spacing dimensions or pitch, such as S_1 and P_1 , becomes increasingly important. This invention grew out of the need to reduce the size of integrated circuits, and particularly the need to reduce spacing dimensions and pitches between adjacent devices over a semiconductor wafer.

20 SUMMARY OF THE INVENTION

The invention includes semiconductor processing methods and related integrated circuitry in which a plurality of patterned device outlines are formed over a semiconductor substrate. Electrically insulative partitions or spacers are then formed on at least a portion

1 of the patterned device outlines, after which a plurality of substantially
2 identically shaped devices are formed relative to the patterned device
3 outlines. Individual formed devices are spaced from at least one other
4 of the devices by a distance substantially no more than a width of one
5 of the electrically insulative spacers.

6 According to one aspect of the invention, elongated electrically
7 conductive lines are formed. According to another aspect of the
8 invention, capacitors are formed. In one preferred implementation of
9 the latter aspect, a pair of adjacent capacitor containers are formed
10 over a substrate by etching a first capacitor container opening having
11 at least one sidewall. An electrically insulative spacer is formed over
12 the sidewall. A second capacitor container opening is etched selectively
13 relative to the spacer. Capacitors are then formed in the capacitor
14 containers in a manner such that adjacent capacitors have a separation
15 distance which is substantially no greater than the width of the spacer
16 between the adjacent capacitors.

17 A novel masking layout is provided which allows capacitors to be
18 formed in a manner which reduces device pitch by almost 50%. Such
19 is particularly adaptive for use in fabrication of DRAM circuitry.
20

21 **BRIEF DESCRIPTION OF THE DRAWINGS**

22 Preferred embodiments of the invention are described below with
23 reference to the following accompanying drawings.
24

1 Fig. 1 is a top plan view of a prior art semiconductor wafer
2 fragment atop which a plurality of masking layers are formed, and is
3 discussed in the "Background" section above.

4 Fig. 2 is a side sectional view of the Fig. 1 prior art
5 semiconductor wafer taken along line 2-2 in Fig. 1.

6 Fig. 3 is a view of the Fig. 1 prior art semiconductor wafer
7 fragment at a processing step subsequent to that shown in Fig. 1.

8 Fig. 4 is a top plan view of a semiconductor wafer fragment atop
9 which a plurality of masking layers are formed at one processing step
10 in accordance with one aspect of the invention.

11 Fig. 5 is a side view of the Fig. 4 semiconductor wafer fragment.

12 Fig. 6 is a view of the Fig. 5 semiconductor wafer fragment at
13 a processing step subsequent to that shown by Fig. 5.

14 Fig. 7 is a view of the Fig. 5 semiconductor wafer fragment at
15 a processing step subsequent to that shown by Fig. 6.

16 Fig. 8 is a view of the Fig. 5 semiconductor wafer fragment at
17 a processing step subsequent to that shown by Fig. 7.

18 Fig. 9 is a view of the Fig. 5 semiconductor wafer fragment at
19 a processing step subsequent to that shown by Fig. 8.

20 Fig. 10 is a top plan view of the Fig. 9 semiconductor wafer
21 fragment.

22 Fig. 11 is a view of a semiconductor wafer fragment at one
23 processing step in accordance with another aspect of the invention.

1 Fig. 12 is a view of the Fig. 11 semiconductor wafer fragment at
2 a processing step subsequent to that shown by Fig. 11.

3 Fig. 13 is a view of the Fig. 11 semiconductor wafer fragment at
4 a processing step subsequent to that shown by Fig. 12.

5 Fig. 14 is a view of the Fig. 11 semiconductor wafer fragment at
6 a processing step subsequent to that shown by Fig. 13.

7 Fig. 15 is a view of the Fig. 11 semiconductor wafer fragment at
8 a processing step subsequent to that shown by Fig. 14.

9 Fig. 16 is a view of the Fig. 11 semiconductor wafer fragment at
10 a processing step subsequent to that shown by Fig. 15.

11 Fig. 17 is a view of the Fig. 11 semiconductor wafer fragment at
12 a processing step subsequent to that shown by Fig. 16.

13 Fig. 18 is a view of the Fig. 11 semiconductor wafer fragment at
14 a processing step subsequent to that shown by Fig. 17.

15 Fig. 19 is a top plan view of a portion of a semiconductor mask
16 layout in accordance with one aspect of the invention.

17 Fig. 20 is a top plan view of the Fig. 19 semiconductor mask
18 layout with a portion highlighted for purposes of discussion.

19 Fig. 21 is a view of a portion of the Fig. 20 semiconductor mask
20 layout highlighted portion.

1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

2 Referring initially to Figs. 4 and 5, a plurality of patterned device
3 outlines 32 are photolithographically formed over a semiconductive
4 substrate 34. In the context of this document, the term "semiconductive
5 substrate" is defined to mean any construction comprising semiconductive
6 material, including, but not limited to, bulk semiconductive materials
7 such as a semiconductive wafer (either alone or in assemblies comprising
8 other materials thereon), and semiconductive material layers (either alone
9 or in assemblies comprising other materials). The term "substrate" refers
10 to any supporting structure, including, but not limited to, the
11 semiconductive substrates described above. In this illustrated and
12 preferred example, the material constituting outlines 32 is preferably of
13 the type which can be etched selectively relative to substrate 34. Such
14 outlines define areas over substrate 34 in which conductive lines are to
15 be formed. Such patterned device outlines are, dimension-wise,
16 substantially the same as those set forth with regard to patterned
17 masking layers 26 in Figs. 1-3.

18 Referring to Fig. 6, an electrically insulative material such as SiO₂
19 or Si₃N₄ is formed over lines 32 and substrate 34 and subsequently
20 anisotropically etched to provide a plurality of sidewall spacers 36 on
21 at least a portion, and preferably all, of pattern device outlines 32.
22 For purposes of the ongoing discussion, patterned device outlines 32
23 define male patterns between which female patterns 38 are also formed.
24 Accordingly, an array of alternating male/female patterns are formed

1 over the substrate wherein sidewall spacers 36 are formed in female
2 patterns 38.

3 Referring to Fig. 7, and after forming sidewall spacers 36, male
4 patterns or patterned device outlines 32 are removed as by suitable
5 etching techniques. The etch preferably etches device outlines 32
6 relative to the material forming spacers 36 and the substrate 34. Such
7 leaves behind a plurality of upstanding sidewall spacers 36 which
8 effectively define thin electrically insulative partitions between which a
9 plurality of devices are to be formed. As shown, the distance or
10 lateral spacing between adjacent spacers varies from spacer-to-spacer.
11 According to one preferred aspect, a plurality of spaces 40a through 40i
12 are provided wherein adjacent spaces, such as 40a and 40b differ
13 slightly in lateral width dimension, while alternate spaces such as 40a
14 and 40c have as shown substantially the same lateral width dimension.

15 Referring to Fig. 8, a conductive material 42 is formed over
16 substrate 34 and sidewall spacers 36 and preferably completely fills
17 spaces 40a through 40i. An example material for layer 32 is
18 conductively doped polysilicon.

19 Referring to Fig. 9, conductive material 42 is etched back as by
20 suitable methods such as a chemical-mechanical polish (CMP) or dry
21 etching as well known in the art. Such forms a plurality of
22 substantially identically shaped circuit devices relative to the patterned
23 device outlines 32 (Fig. 6). In this embodiment, such devices are
24 conductive lines 44 which are spaced laterally from one another a

1 distance which is no greater than a width of one of the electrically
2 insulative sidewall spacers 36 therebetween. As so formed, immediately
3 adjacent conductive lines of the plurality of lines formed have a
4 pitch P_2 which is substantially no greater than a lateral line width L_2
5 plus a width W_2 of the spacer 36 which is positioned between the
6 adjacent lines. As compared to the pitch P_1 (Fig. 3) of the prior
7 circuit devices, pitch P_2 represents a reduction in pitch which
8 approaches fifty percent. Such achieved pitch reductions are without
9 regard to the prior art photolithographic spacing constraints imposed on
10 semiconductor processing. As mentioned above, the spacing between
11 adjacent spacers varies from spacer-to-spacer. Accordingly, the pitch P_2
12 would vary as well. It is possible for the spacing between adjacent
13 spacers to be uniform, however, so that the pitch remains constant
14 across the substrate.

15 Referring to Fig. 10, a top plan view of substrate 34 is shown.
16 Conductive lines 44 collectively define a series of conductive lines which
17 in turn define a device array 46 of substantially identically shaped
18 devices. Array 46 includes the plurality of upstanding spacers 36 and
19 the conductive lines 44 formed intermediate the spacers. In accordance
20 with a preferred aspect of the invention and as described with reference
21 to Fig. 9 above, adjacent lines have a pitch which is substantially no
22 greater than about the distance between a pair of adjacent spacers
23 (corresponding to the line width) plus the width of the spacer
24 therebetween. In the illustrated example, conductive lines 44 are

1 elongated and adjacent conductive lines have different lateral line widths.
2 Additionally, alternate lines have substantially equal lateral line widths.
3 Such variation in line width stems from the manner in which the
4 anisotropically etched sidewall spacers 36 are provided over the
5 substrate, and in particular the lateral spacing of device outlines 32
6 (Fig. 5). As mentioned above, it is possible for the line widths to be
7 substantially equal over the entire substrate.

8 Referring still to Fig. 10, a dashed line 48 traverses device
9 array 46. Individual elongated conductive lines 44 are formed over
10 substrate 34 transversely along line 48. Respective alternate devices
11 along line 48 have a substantially common width dimension therealong
12 and respective adjacent devices have a different width dimension
13 therealong.

14 Referring collectively to Figs. 11-18, a semiconductor processing
15 method of forming a plurality of alternate devices on a substrate in
16 accordance with the above-described principles is described. According
17 to a preferred aspect of the invention, the devices comprise capacitors,
18 and even more preferably comprise capacitors which form part of a
19 dynamic random access memory (DRAM) device. Circuit devices other
20 than the illustrated and described conductive lines and capacitors can
21 be fabricated in accordance with the invention.

22 In accordance with one preferred embodiment, a plurality of
23 capacitor container openings are etched over a substrate in two separate
24 etching steps. Thereafter, corresponding DRAM capacitors are formed

1 within the container openings according to known processing techniques.
2 As so formed, and in accordance with the above-described spacer
3 formation and pitch reduction concepts, a plurality of pairs of adjacent
4 capacitors are formed in respective adjacent capacitor containers which
5 are separated by no more than anisotropically etched, electrically
6 insulative sidewall spacers as will become evident below.

7 Referring specifically to Fig. 11, a semiconductor wafer fragment
8 in process is shown generally at 50 and includes a layer of material 52
9 which may or not may be semiconductive. Transistors forming part of
10 the preferred DRAM circuitry array are not shown, but are formed
11 preferably elevationally below the capacitors described hereafter. Other
12 elevational configurations as between transistors and capacitors are
13 possible. A layer 54, preferably of borophosphosilicate glass (BPSG),
14 is formed over material 52 to a thickness preferably around two
15 microns. A layer of photoresist material 58 formed over the substrate
16 and patterned to define a plurality of bit line contact openings 56 over
17 wafer fragment 50. The illustrated and preferred photoresist
18 material 58 defines a plurality of patterned device outlines 60 over the
19 substrate. Patterned outlines 60 in turn define individual areas over the
20 substrate for supporting a plurality of capacitors to be formed as
21 described below. Preferably, the individual areas defined by outlines 60
22 support two such capacitors as will be apparent.

23 Referring to Fig. 12, layer 54 is anisotropically etched to form bit
24 line contact openings 62 into layer 54. Photoresist material 58 is then

1 stripped and an insulating material is formed over the substrate and
2 into openings 62 and subsequently anisotropically etched to form the
3 illustrated sidewall spacers 64. Thereafter, bit contact material,
4 preferably conductively doped polysilicon, is formed over the substrate
5 and into openings 62. Such material is or may be planarized as by
6 suitable chemical-mechanical polishing to provide the illustrated bit line
7 contacts or plugs 66. A plurality of contacts similar to contacts 66 are
8 formed over the substrate during the same formation steps and bound
9 each area 60 across the substrate in the same manner as the illustrated
10 contacts 66 bound the centermost area 60.

11 Referring to Fig. 13, a first set of capacitor container opening
12 patterns 68 are formed over the substrate and defined by photoresist
13 material 69. The device pattern set forth in Fig. 13 results from a
14 semiconductor mask layout which is shown in Fig. 19 and discussed in
15 detail below. Fig. 13 is a view which is taken along line 13-13 in
16 Fig. 19.

17 Referring to Fig. 14, a first set 70 of capacitor container openings
18 are etched selectively relative to spacers 64 and the conductive
19 contacts 66 through layer 54. Photoresist material 69 is then stripped
20 away. Individual capacitor containers 72 of first set 70 have at least
21 one, and preferably more, upright sidewalls, two of which are illustrated
22 at 74, 76 respectively for each container 72. Upright sidewalls 74 as
23 viewed in Fig. 14 coincide with and are defined by the rightmost
24 sidewall spacer 64 which was previously formed.

Referring to Fig. 15, an electrically insulative material such as silicon nitride is formed over the substrate and subsequently anisotropically etched relative to layer 54, spacers 64, and bit line contacts 66 to form respective partitions or spacers 78, 80. Individual areas defined by outlines 60 are thus partitioned into two parts which are separated from one another by non-conducting partitions 78, 80, respectively, which are formed over and cover sidewalls 74, 76 respectively. As so formed, partitions 78, 80 outline individual container openings of first set 70 in which capacitors are to be formed.

Referring to Fig. 16, remaining BPSG layer 54 is selectively etched or otherwise removed relative to sidewall spacers 64, spacers or partitions 78, 80, and bit line contacts 66 to define a second set 82 of capacitor container openings to respective capacitor containers 84. As so etched, individual second set containers 84 and the respective openings thereof are disposed adjacent respective first set containers 72 to form a pair of containers (only one complete pair 72/84 of which is shown). The leftmost side of Fig. 16 shows a leftmost outline 60 which includes a complete capacitor container 84 and a portion of its paired container 72. Likewise, the rightmost side of Fig. 16 shows a rightmost outline 60 which includes a complete capacitor container 72 and a portion of its paired container 84. Individual containers of a pair are separated therefrom by no more than the width of a non-conducting partition 80. As discussed above with reference to the pitch advantages achieved with conductive lines 44 (Figs. 9 and 10),

such advantages are achieved through the use of spacers or partitions 80 which electrically isolate adjacent capacitors formed in respective areas 60.

Referring to Figs. 17 and 18, electrically conductive container material 86 is formed over the substrate and planarized (Fig. 18) to define a plurality of capacitor storage nodes 81 in preferred container shapes. Subsequently, capacitors are formed according to conventional formation techniques as by provision of a dielectric layer 83 over respective storage nodes 81 and provision of a subsequent polysilicon layer 85 thereover. As so formed, capacitors in respective partitioned parts of the area defined by outlines 60 are separated from immediately adjacent capacitors or have a closest separation distance which is substantially no greater than the width of the partition or spacer between the capacitors.

Referring to Fig. 19, a diagrammatic semiconductor mask layout and DRAM array is designated generally by reference numeral 88. Layout 88 is utilized to enable the above-described container openings to be selectively, alternately formed or etched in the two described separate etching steps. For purposes of clarity, Fig. 13 is taken along line 13-13 in Fig. 19 at a processing point just after the patterning of photoresist material 69 (Fig. 13) with layout 88. Layout 88 enables capacitors having unique, space-saving geometries to be formed over the substrate. According to a preferred aspect of the invention, the electrically insulative partitions 78, 80 (Fig. 16) are formed between

1 adjacent capacitors intermediate the two etching steps which form or
2 define the areas over the substrate in which the capacitors will be
3 formed. The partitions 78, 80 are not shown for clarity in Fig. 19.

4 Mask layout 88 includes a plurality of rows such as those
5 illustrated at R₁, R₂, R₃, and R₄. The mask layout also includes a
6 plurality of columns such as those illustrated at C₁, C₂, C₃, C₄, C₅, C₆,
7 and C₇. A plurality of masked areas 90 and a plurality of adjacent
8 unmasked areas 92 are defined by the layout. Unmasked areas 92
9 correspond to capacitor container opening patterns 68 in Fig. 13 and
10 masked areas 90 correspond to photoresist material 69. Layout 88
11 enables a plurality of capacitors to be formed, preferably as part of a
12 DRAM array over the substrate, wherein respective alternate capacitors
13 in a row, such as rows R₁-R₄ have substantially similar lateral width
14 profiles transverse the row. Preferably, respective adjacent capacitors
15 in a row have different lateral width profiles transverse the row. The
16 illustrated and preferred lateral width profiles when viewed from a point
17 above the substrate approximate triangles which are oriented in a top-
18 to-bottom fashion across the row. Additionally, individual defined areas
19 in which the preferred capacitor pairs are to be formed (corresponding
20 to the view taken along line 13-13 in column C₅) approximate a
21 diamond shape with such shape having at its respective corners, bit line
22 contacts 94 which are formed as described above. For purposes of the
23 ongoing discussion, each of columns C₁-C₇ are formed along a generally
24 straight line which is generally transverse each of rows R₁-R₄. Further,

the array of capacitor pairs to be formed are formed along individual lines which contain at least one of the pairs of capacitors. As such, the array is defined by a plurality of the lines (corresponding to the plurality of the columns) which contain a plurality of capacitors which are separated by substantially no more than an electrically insulative anisotropically etched spacer as described above. Underlying word lines are shown by dashed lines 93 and interconnect associated transistors formed relative to the substrate. Individual bit lines are not specifically shown but are subsequently formed and oriented generally transversely relative to word lines 93.

Referring to Fig. 20, mask layout 88 defines in part a DRAM array which includes a plurality of six-capacitor geometries which are to be formed over the substrate. A representative of one of the geometries is indicated generally by reference numeral 96 and a plurality of adjacent or other geometries are shown in phantom lines. The illustrated and preferred six-capacitor geometries are, in turn, defined by a plurality of individual polygonal capacitor geometries shown collectively at 98 through 108. Preferably, collective individual capacitor geometries 98 through 108 approximate a hexagon individual sides of which are defined by a side of a different respective one of the individual polygonal capacitor geometries. For example, six-capacitor geometry or hexagon 96 includes six sides collectively shown at 96a, 96b, 96c, 96d, 96e, and 96f. Each of such sides is defined by a different respective one of the individual sides of the individual

1 polygonal capacitor geometries 98 through 108. According to a
2 preferred aspect of the invention, individual polygonal capacitor
3 geometries 98 through 108, when viewed outwardly of the substrate
4 approximate a wedge or wedge-shape. Even more preferably, such
5 individual geometries approximate a triangle which, most preferably, is
6 an isosceles triangle. Further, individual approximated isosceles triangles
7 include equal adjacent angles θ which approximate a range of between
8 about 50° to 70° . Such equal adjacent angles are shown for individual
9 geometries 100, 104, and 108. Even more preferably, such equal
10 adjacent angles approximate an angle of about 65° . Individual
11 geometries 98 through 102 and 104 through 108 respectively, are
12 preferably arranged in a top-to-bottom orientation such that hexagon 96
13 can be bisected, as by dashed line 110, into halves which contain
14 exactly three individual polygonal capacitor geometries. In the illustrated
15 and preferred hexagon, one of the halves, a top half as viewed in
16 Fig. 20 contains individual geometries 98, 100, and 102. The other of
17 the halves, a bottom half, contains geometries 104, 106, and 108.

18 Referring to Fig. 21, the top half containing geometries 98, 100,
19 and 102 is shown. Such comprises a three-capacitor geometry 112, a
20 plurality of which are disposed over the substrate. Preferably,
21 three-capacitor geometry 112, when viewed outwardly of the substrate
22 defines a pair of overlapping approximated parallelograms, the
23 intersection of which approximates a triangle. The first of such
24 parallelograms is shown at 114. The second of such parallelograms is

1 shown at 116. Parallelogram 114 includes sides 114a, 114b, 114c,
2 and 114d. Parallelogram 116 includes sides 116a, 116b, 116c, and 116d.
3 The parallelograms share sides 114b and 116d. As shown, each
4 approximated parallelogram is bounded at a respective one of its
5 corners by a bit line contact 94. The approximated triangle defined by
6 the intersection of parallelograms 114, 116 includes sides 114c, 116c and
7 shared sides 114b/116d. For purposes of ongoing discussion, a plurality
8 of capacitor pairs are selectively and alternately etched over the
9 substrate along etch axes which are generally orthogonal relative to the
10 substrate and into the plane of the page upon which Fig. 21 appears.
11 Such capacitor pairs can approximate the above described parallelogram
12 and would include the individual capacitors etched as a result of
13 individual geometries 98, 100, or alternatively 100, 102.

14 Referring to both Figs. 16 and 19, a DRAM array is formed atop
15 a substrate and includes a first set of capacitors formed in first set
16 capacitor openings 70 over the substrate. A second set of capacitors
17 are formed over the substrate and in second set capacitor openings 82.
18 Individual capacitors of the first set are bounded by at least three
19 capacitors from the second set (Fig. 19). Preferably, individual first set
20 capacitors have a closest separation distance from at least one of the
21 three bounding capacitors which is substantially no more than a width
22 of an electrically insulative anisotropically etched spacer. One such
23 width is indicated in Fig. 16 at 80. Even more preferably, individual
24 bounded first set capacitors have closest separation distances from no

1 less than two and preferably three of the bounding capacitors which are
2 no more than the width of an electrically insulative anisotropically
3 etched spacer formed or provided between the respective capacitors.

4 The above described semiconductor device forming methods and
5 integrated circuitry formed thereby constitute an improvement which
6 relates to device spacing over a substrate. Such improvement enables
7 device pitch to be reduced by almost fifty percent or more which
8 represents a substantial space savings over heretofore available methods
9 and devices.

10 In compliance with the statute, the invention has been described
11 in language more or less specific as to structural and methodical
12 features. It is to be understood, however, that the invention is not
13 limited to the specific features shown and described, since the means
14 herein disclosed comprise preferred forms of putting the invention into
15 effect. The invention is, therefore, claimed in any of its forms or
16 modifications within the proper scope of the appended claims
17 appropriately interpreted in accordance with the doctrine of equivalents.

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1 **CLAIMS:**

2 1. A method of forming integrated circuit devices comprising:
3 forming a plurality of patterned device outlines over a
4 semiconductive substrate;
5 forming electrically insulative spacers on at least a portion of the
6 patterned device outlines; and
7 forming a plurality of substantially identically shaped devices
8 relative to the patterned device outlines, at least two individual devices
9 of the plurality being spaced from one another by a distance no greater
10 than a width of an interposed electrically insulative spacer.

11
12 2. The method of forming integrated circuit devices of claim 1,
13 wherein the devices are elongated electrically conductive lines.

14
15 3. The method of forming integrated circuit devices of claim 1,
16 wherein the devices include capacitors of a DRAM array.

17
18 4. The method of forming integrated circuit devices of claim 1,
19 wherein the plurality of devices are formed along a line, respective
20 alternate devices along the line having a substantially common width
21 dimension.

1 5. The method of forming integrated circuit devices of claim 1,
2 wherein the plurality of devices are formed along a line, respective
3 adjacent devices along the line having different width dimensions.

4

5 6. The method of forming integrated circuit devices of claim 1,
6 wherein the devices include capacitors of a DRAM array, the capacitors
7 being formed in rows, respective alternate capacitors in a row having
8 substantially similar width profiles transverse the row.

9

10 7. The method of forming integrated circuit devices of claim 1,
11 wherein the devices include capacitors of a DRAM array, the capacitors
12 being formed in rows, adjacent capacitors in a row having different
13 width profiles transverse the row.

14

15 8. The method of forming integrated circuit devices of claim 1,
16 wherein the devices include capacitors of a DRAM array, the capacitors
17 being formed in rows, respective alternate capacitors in a row having
18 substantially similar width profiles transverse the row, adjacent capacitors
19 in the row having different width profiles transverse the row.

1 9. A method of forming a plurality of integrated circuitry
2 devices on a substrate comprising:

3 forming a plurality of spaced, upstanding, anisotropically etched
4 electrically insulative spacers; and

5 forming a plurality of devices over the substrate intermediate the
6 spacers with the spacers being positioned intermediate adjacent devices,
7 adjacent devices having a pitch which is substantially no greater than
8 about the distance between a pair of adjacent spacers plus the width
9 of the spacer between the adjacent devices.

10
11 10. The method of forming a plurality of integrated circuitry
12 devices of claim 9, wherein the devices are conductive lines.

13
14 11. The method of forming a plurality of integrated circuitry
15 devices of claim 9, wherein the devices are capacitors.

16
17 12. The method of forming a plurality of integrated circuitry
18 devices of claim 9, wherein the devices are capacitors of a DRAM
19 device.

1 13. A DRAM capacitor forming method comprising the steps of:
2 forming a plurality of patterned outlines over a semiconductive
3 substrate to define individual areas for a plurality of capacitors to be
4 formed;

5 partitioning said individual areas from one another by a non-
6 conducting partition; and

7 forming capacitors in at least some of the respective partitioned
8 areas, the respective capacitors being separated from immediately
9 adjacent capacitors by a distance substantially no greater than the width
10 of the partition therebetween.

11
12 14. The DRAM capacitor forming method of claim 13, wherein
13 the partitioning step comprises:

14 etching a first set of capacitor container openings, individual
15 container openings having at least one upright sidewall; and

16 etching a second set of capacitor container openings adjacent
17 respective first set container openings and separated therefrom by
18 respective non-conducting partitions.

1 15. The DRAM capacitor forming method of claim 13, wherein
2 the partitioning step comprises:

3 etching a first set of capacitor container openings, individual
4 container openings having at least one upright sidewall;

5 forming insulative material over the substrate;

6 anisotropically etching the insulative material to provide partitions
7 over at least some of the upright sidewalls; and

8 etching a second set of capacitor container openings immediately
9 adjacent the provided partitions.

10
11 16. The DRAM capacitor forming method of claim 13 wherein
12 individual defined areas, when viewed from a point above the substrate,
13 approximate diamond shapes.

14
15 17. A DRAM capacitor forming method comprising the steps of:
16 forming a pair of adjacent capacitor containers over a substrate
17 by etching a first capacitor container opening having at least one
18 upright sidewall;

19 forming an electrically insulative spacer on the upright sidewall;

20 selectively etching a second capacitor container opening adjacent
21 the formed spacer;

22 forming capacitors in the capacitor containers, adjacent capacitors
23 having a separation distance therebetween which is substantially no
24 greater than the width of the spacer between the adjacent capacitors.

1 18. The DRAM capacitor forming method of claim 17, wherein
2 the step of forming the electrically insulative spacer comprises:
3 forming an insulative material over the substrate; and
4 anisotropically etching the insulative material to form the spacer.
5

6 19. The DRAM capacitor forming method of claim 17, wherein
7 individual capacitor containers are generally triangularly shaped when
8 viewed from a point above the substrate.
9

10 10 20. A method of forming capacitors comprising forming an array
11 of capacitor pairs on a substrate, the array being defined in part by a
12 plurality of lines, individual lines containing at least one pair of
13 capacitors, individual capacitors of said at least one pair of capacitors
14 being separated by substantially no more than an electrically insulative
15 anisotropically etched spacer disposed therebetween.
16

17 17 21. The method of forming capacitors of claim 20 further
18 comprising prior to forming the array of capacitor pairs, forming a
19 plurality of bit line contacts in individual lines, individual capacitor pairs
20 being bounded by at least two bit line contacts.
21
22
23
24

1 22. The method of forming capacitors of claim 20 wherein
2 individual capacitor pairs have a pitch no greater than about a lateral
3 width dimension of one of the capacitors plus the width of the
4 anisotropically etched spacer between the capacitors of an individual
5 pair.

6

7 23. A DRAM capacitor array comprising:
8 a substrate;
9 a first set of capacitors over the substrate; and
10 a second set of capacitors over the substrate, individual capacitors
11 of the first set being bounded by at least three capacitors from the
12 second set, individual first set capacitors having a closest separation
13 distance from at least one of the three capacitors from the second set
14 which is substantially no more than a width of an interposed electrically
15 insulative anisotropically etched spacer.

16

17 24. The DRAM capacitor array of claim 23, wherein individual
18 bounded first set capacitors have closest separation distances from no
19 less than two of the three capacitors from the second set, said closest
20 separation distances being substantially no more than a width of an
21 interposed electrically insulative anisotropically etched spacer.

22

23

24

1 25. The DRAM capacitor array of claim 23, wherein individual
2 bounded first set capacitors have closest separation distances from the
3 three capacitors from the second set which are substantially no more
4 than a width of an interposed electrically insulative anisotropically etched
5 spacer.

6

7 26. A method of forming a plurality of capacitors in a
8 semiconductor memory device comprising the steps of:

9 selectively removing substrate material to define a first set of
10 containers;

11 forming sidewall spacers adjacent container sidewalls;

12 selectively removing remaining substrate material adjacent the
13 spacers to define a second set of containers; and

14 forming capacitors in the containers separated only by the spacers.

15

16 27. The method of forming a plurality of capacitors of claim 26
17 further comprising prior to defining the first set of containers:

18 forming a plurality of bit line contact openings over the substrate,
19 individual bit line contact openings having at least one sidewall; and

20 covering the at least one sidewall of the plurality of bit line
21 contact openings with an insulating material.

1 28. The method of forming a plurality of capacitors of claim 26
2 further comprising prior to defining the first set of containers:

3 forming a plurality of bit line contact openings over the substrate,
4 individual bit line contact openings having at least one sidewall;

5 covering the at least one sidewall of the plurality of bit line
6 contact openings with an insulating material;

7 etching the insulating material to form sidewall spacers; and

8 forming electrically conductive material in the bit line contact
9 openings to provide bit line contacts,

10 wherein the defining of the first set of containers includes
11 selectively etching the first set of containers relative to the sidewall
12 spacers and the electrically conductive material of the bit line contacts.

13
14 29. A DRAM capacitor forming method comprising forming a
15 plurality of pairs of adjacent capacitors in respective adjacent capacitor
16 containers separated by substantially no more than anisotropically etched
17 sidewall spacers.

18
19 30. The DRAM capacitor forming method of claim 29, wherein
20 individual pairs of adjacent capacitors, when viewed from a point over
21 the substrate are approximately diamond shaped.

1 31. The DRAM capacitor forming method of claim 29 further
2 comprising forming a plurality of bit line contact openings over the
3 substrate prior to forming the capacitor pairs.

4

5 32. The DRAM capacitor forming method of claim 29 further
6 comprising forming a plurality of bit line contact openings over the
7 substrate prior to forming the capacitor pairs, and wherein individual
8 pairs of adjacent capacitors, when viewed from a point over the
9 substrate are approximately diamond shaped, individual bit line contact
10 openings being positioned in respective corners of the diamonds.

11

12 33. A capacitor array for a DRAM comprising:
13 a plurality of bit line contacts to a substrate; and
14 a plurality of capacitor pairs selectively alternately etched over a
15 substrate along etch axes which are generally orthogonal relative to the
16 substrate, individual capacitor pairs having an area which, when viewed
17 from outwardly of the substrate from a point on such etch axes,
18 approximates a parallelogram which is bounded at a plurality of its
19 corners by individual bit line contacts.

1 34. A processing method of forming a capacitor array for a
2 DRAM comprising:

3 forming a plurality of bit line contacts to a substrate; and
4 forming a plurality of capacitor pairs, individual pairs being
5 selectively alternately etched over a substrate and along etch axes which
6 are generally orthogonal relative to the substrate, individual capacitor
7 pairs having an area which, when viewed from outwardly of the
8 substrate from a point on such etch axes, approximates a parallelogram
9 which is bounded at a plurality of its corners by individual bit line
10 contacts.

11
12 35. A method of forming a plurality of DRAM capacitors
13 comprising:

14 etching capacitor container openings for an array in a substrate
15 in at least two separate etching steps, and forming electrically insulative
16 partitions between adjacent capacitors intermediate the two etching steps.

17
18 36. The method of claim 35 wherein the forming electrically
19 insulative partitions step comprises:

20 forming insulative material over the substrate; and
21 conducting an anisotropic etch of the insulative material to a
22 degree sufficient to leave the partitions.

1 37. A processing method of forming a plurality of DRAM
2 capacitors comprising etching capacitor container openings for a capacitor
3 array in a substrate in two separate etching steps.

4

5 38. A DRAM capacitor array comprising:

6 a plurality of 6-capacitor geometries over a substrate, individual
7 6-capacitor geometries being defined by a plurality of individual generally
8 polygonal capacitor geometries, and

9 further, individual 6-capacitor geometries, when viewed from above
10 the substrate, approximating a hexagon, each individual side of which
11 being defined by a side of a different respective one of the individual
12 polygonal capacitor geometries.

13

14 39. The DRAM capacitor array of claim 38, wherein individual
15 polygonal capacitor geometries, when viewed from above the substrate
16 approximate a wedge shape.

17

18 40. The DRAM capacitor array of claim 38, wherein individual
19 polygonal capacitor geometries, when viewed from above the substrate
20 approximate a triangle.

21

22 41. The DRAM capacitor array of claim 38, wherein individual
23 polygonal capacitor geometries, when viewed from above the substrate
24 approximate an isosceles triangle.

1 42. The DRAM capacitor array of claim 38, wherein individual
2 polygonal capacitor geometries, when viewed from above the substrate
3 approximate an isosceles triangle equal adjacent angles of which
4 approximate a range of between about 50° to 70°.

5
6 43. The DRAM capacitor array of claim 38, wherein individual
7 polygonal capacitor geometries, when viewed from above the substrate
8 approximate an isosceles triangle equal adjacent angles of which
9 approximate about 65°.

10
11 44. The DRAM capacitor array of claim 38, wherein the
12 hexagon can be bisected into halves containing exactly three individual
13 polygonal capacitor geometries.

14
15 45. A DRAM capacitor array comprising:
16 a plurality of 3-capacitor geometries over a substrate, individual
17 3-capacitor geometries, when viewed from above the substrate being
18 defined by a pair of overlapping approximated parallelograms, the
19 intersection of which approximates a triangle.

1 46. A method of forming adjacent devices over a substrate
2 comprising:

3 lithographically forming an array of patterned device outlines over
4 a substrate, the outlines defining alternating male/female patterns;

5 forming electrically insulative sidewall spacers in the female
6 patterns;

7 after forming the electrically insulative sidewall spacers, removing
8 the male patterns; and

9 after removing the male patterns, forming circuit devices adjacent
10 the spacers.

11
12 47. An integrated device array of substantially identically shaped
13 devices comprising:

14 a plurality of spaced upstanding anisotropically etched electrically
15 insulative spacers; and

16 a plurality of devices formed over the substrate intermediate the
17 spacers with the spacers being positioned intermediate adjacent devices,
18 adjacent devices having a pitch which is substantially no greater than
19 about the distance between a pair of adjacent spacers plus the width
20 of the spacer between the adjacent devices.

21
22 48. The integrated device array of claim 47, wherein the devices
23 are conductive lines.

1 49. The integrated device array of claim 47, wherein the devices
2 are capacitors.

3
4 50. The integrated device array of claim 47, wherein the devices
5 are capacitors and the device array forms part of a DRAM device.

1 **ABSTRACT OF THE DISCLOSURE**

2 Semiconductor processing methods include forming a plurality of
3 patterned device outlines over a semiconductor substrate, forming
4 electrically insulative partitions or spacers on at least a portion of the
5 patterned device outlines, and forming a plurality of substantially
6 identically shaped devices relative to the patterned device outlines.
7 Individual formed devices are spaced from at least one other of the
8 devices by a distance no more than a width of one of the electrically
9 insulative spacers. In such manner, device pitch is reduced by almost
10 fifty percent. According to one aspect, elongated electrically conductive
11 lines are formed. According to another aspect, capacitors are formed
12 which, according to a preferred embodiment form part of a dynamic
13 random access memory (DRAM) array.

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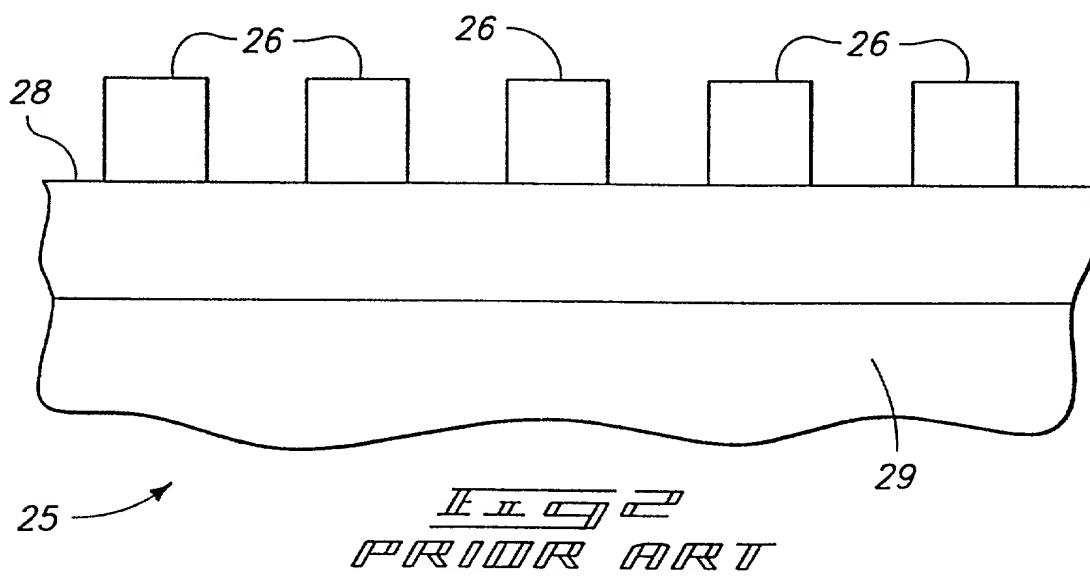
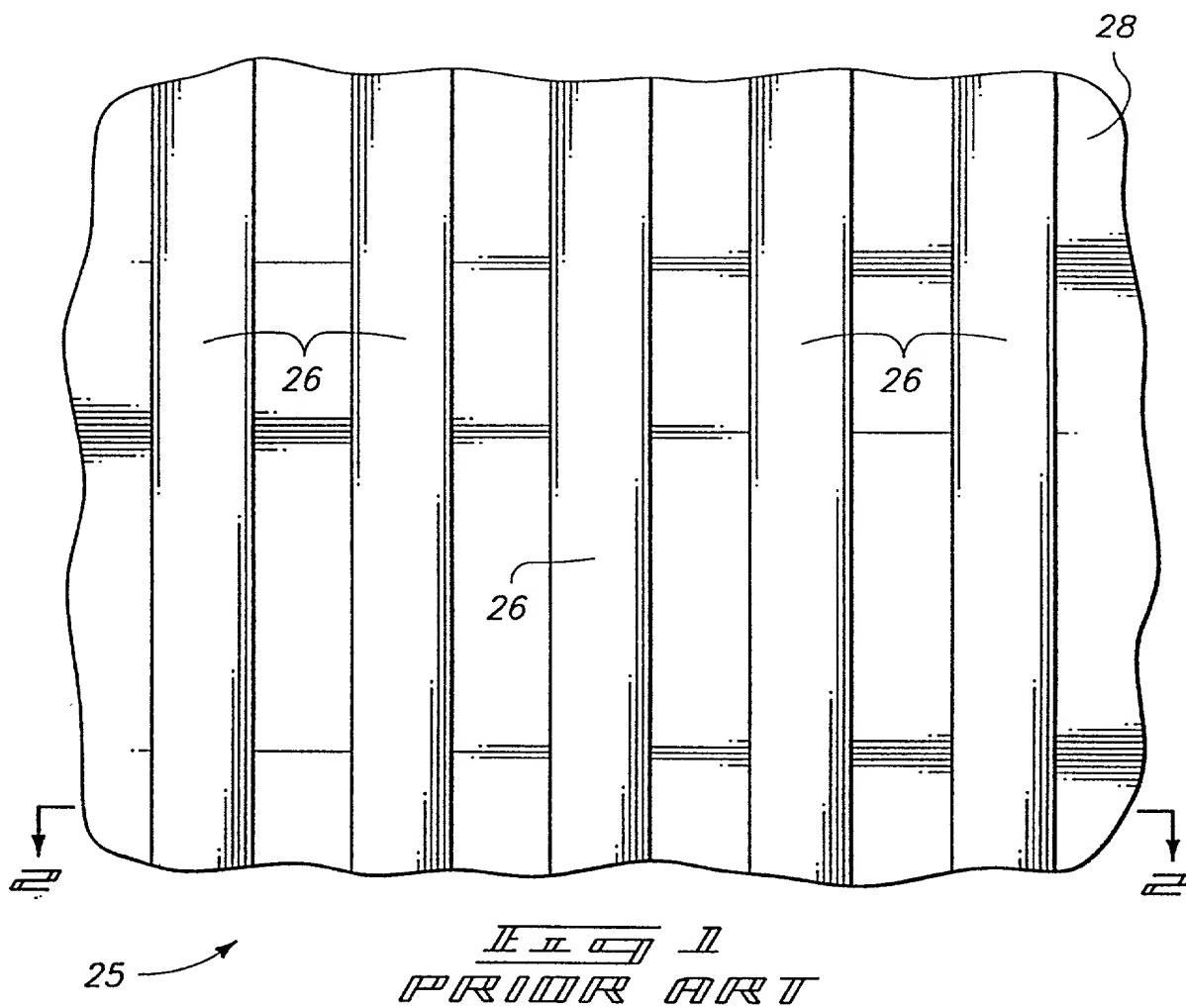
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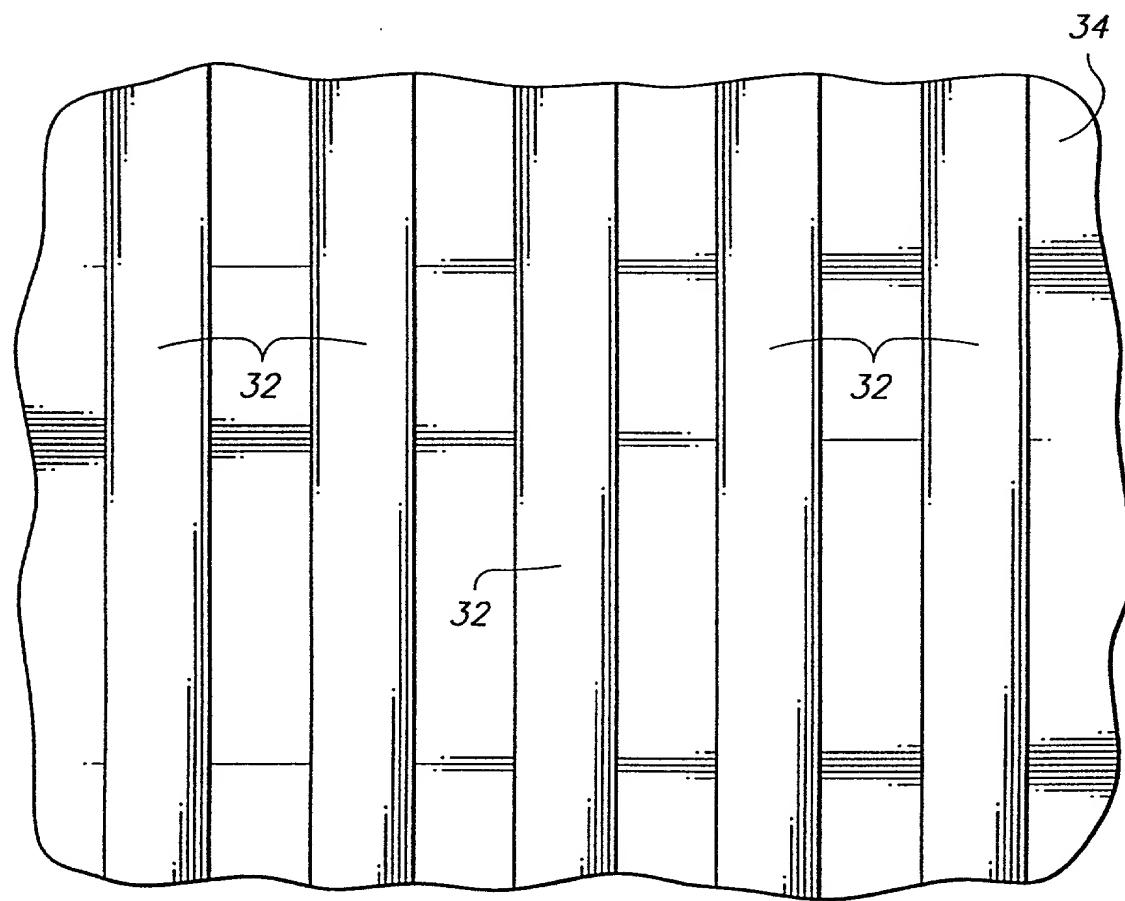
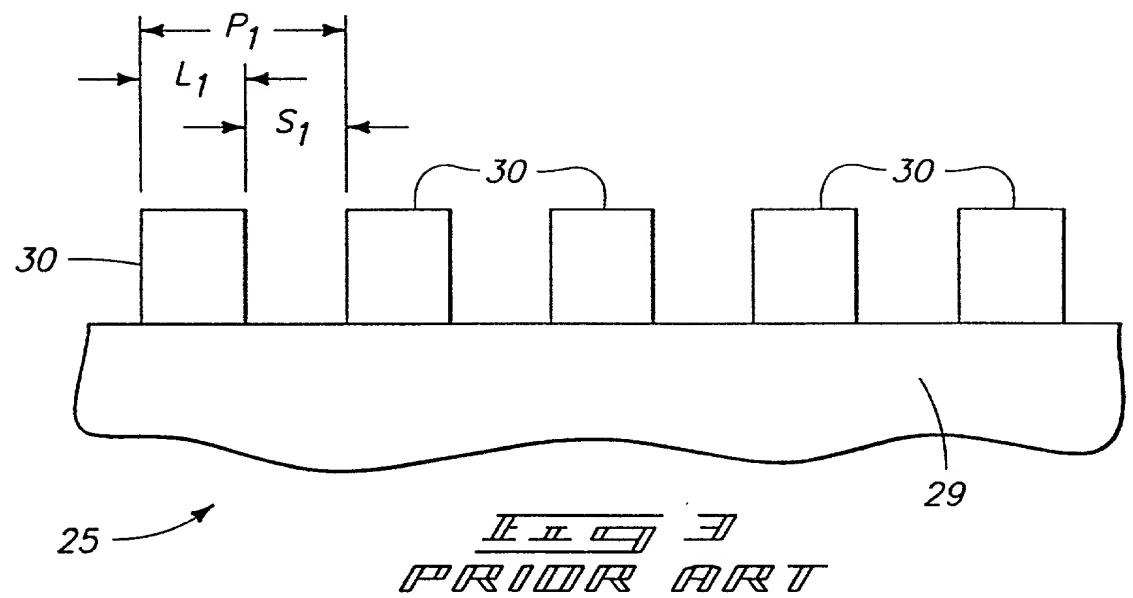
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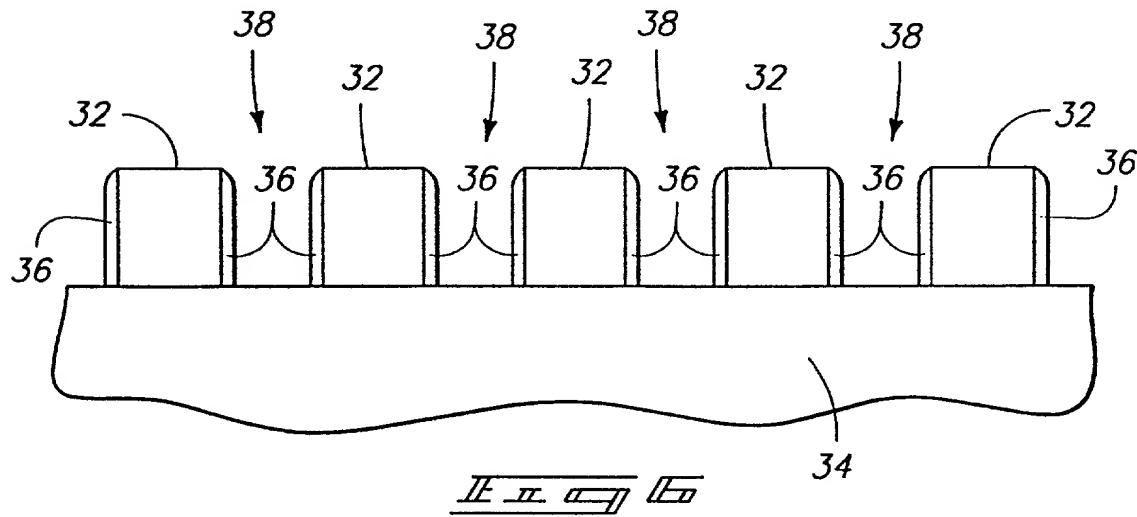
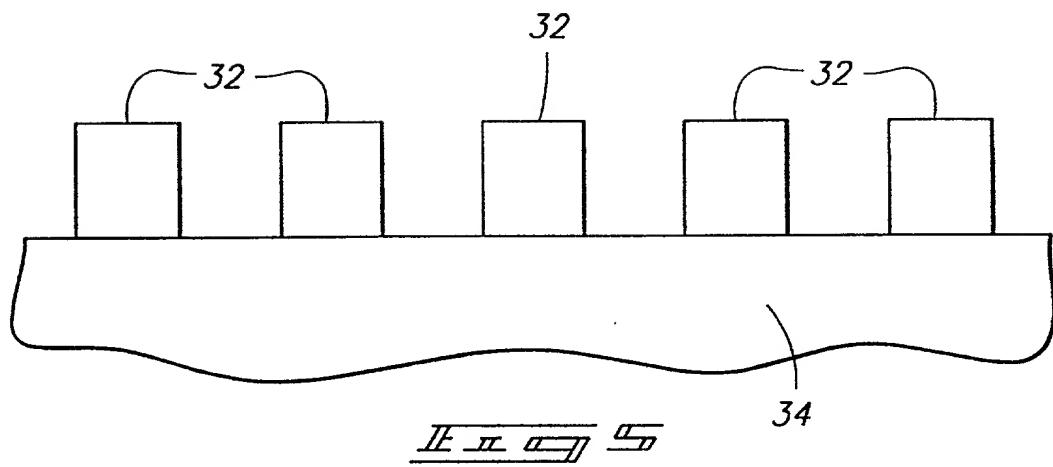
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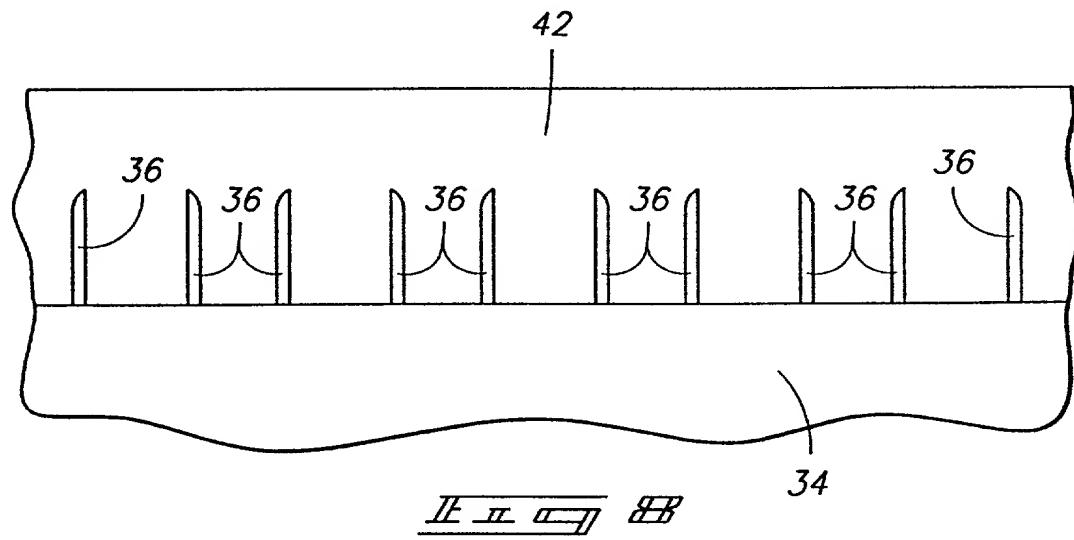
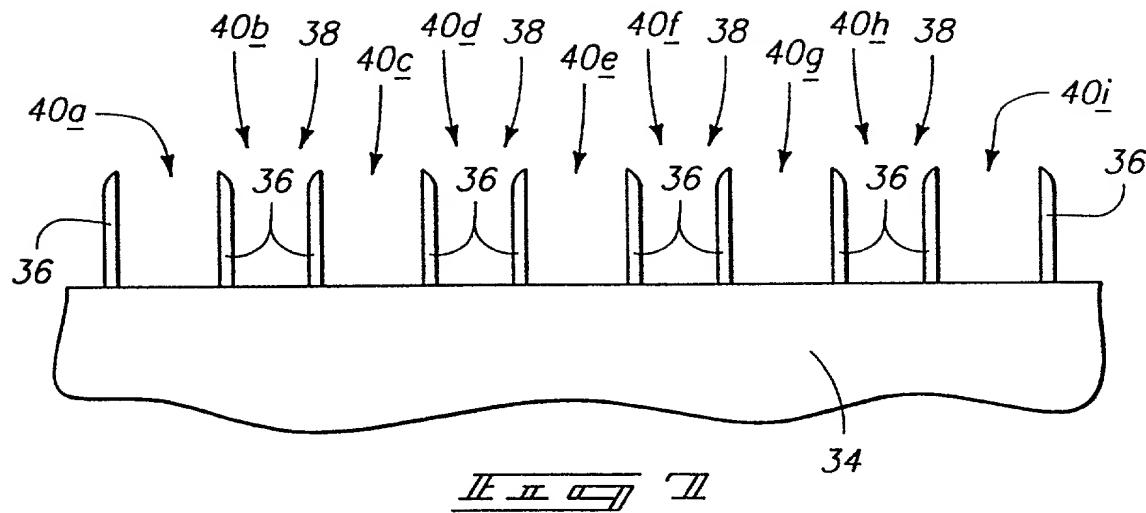
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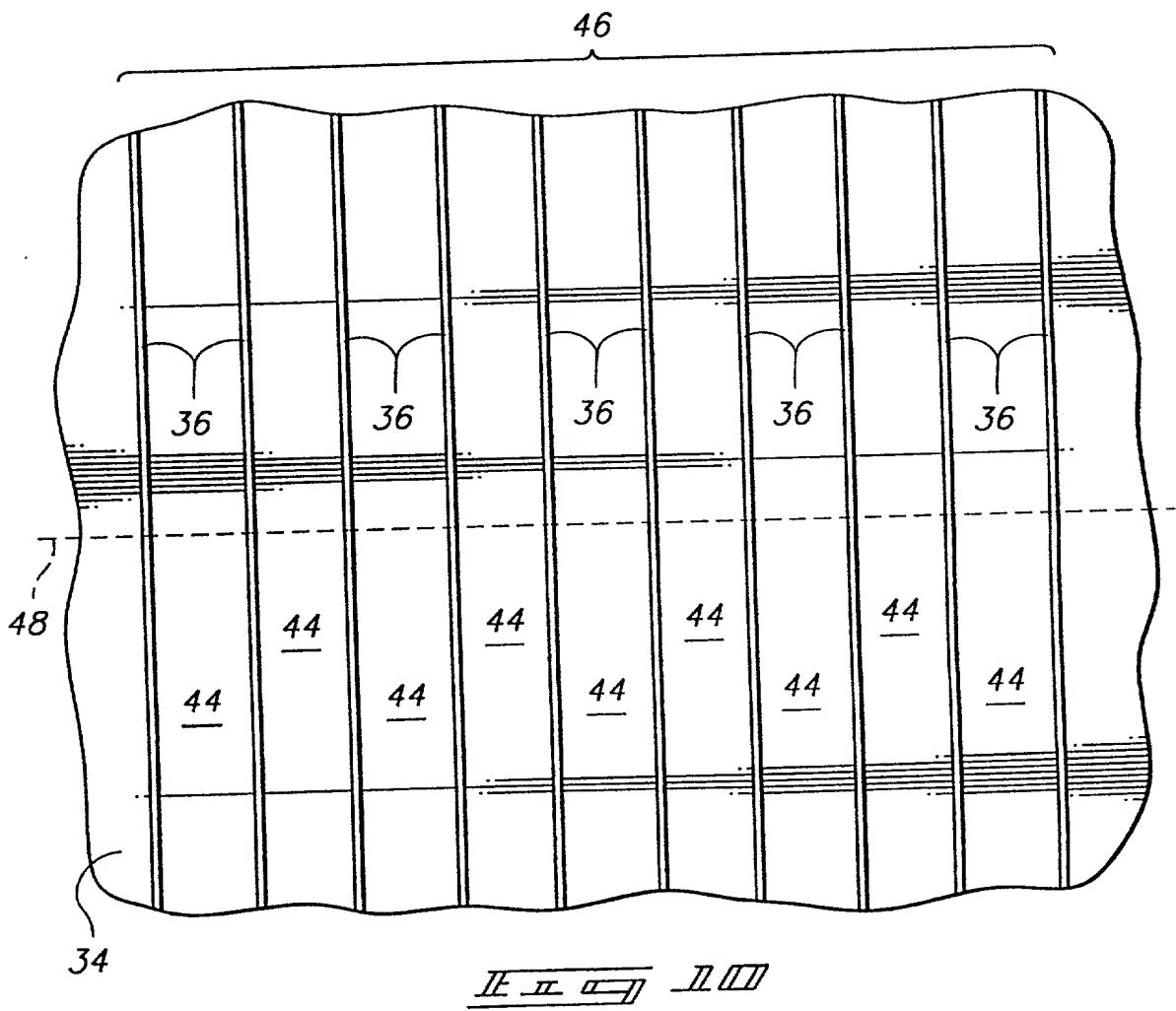
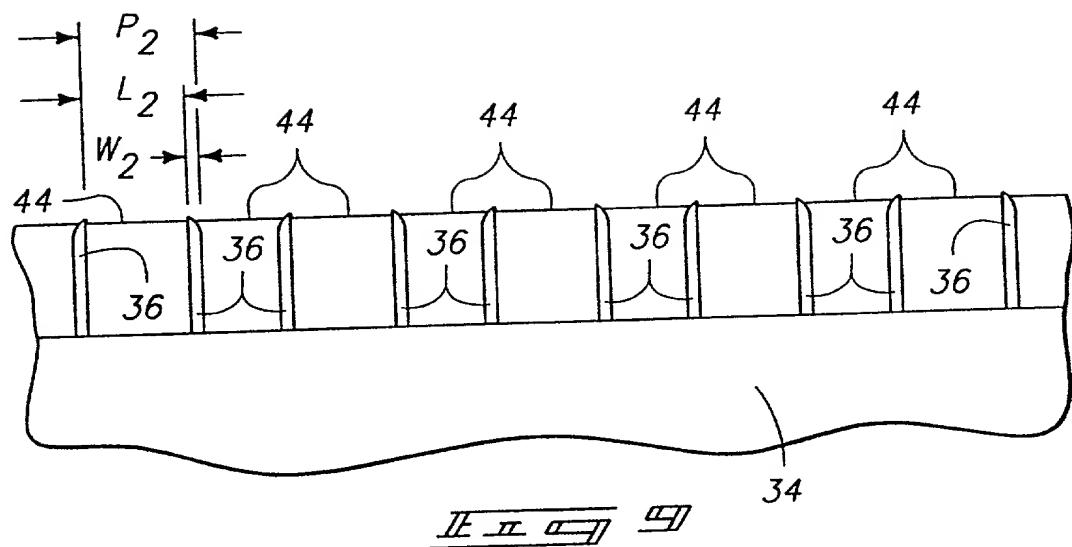
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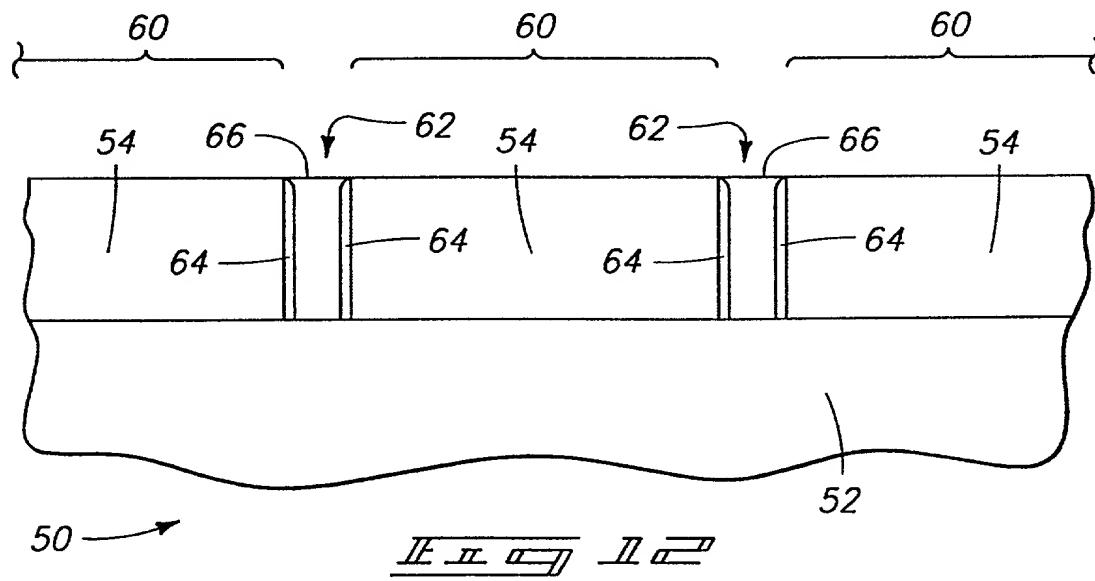
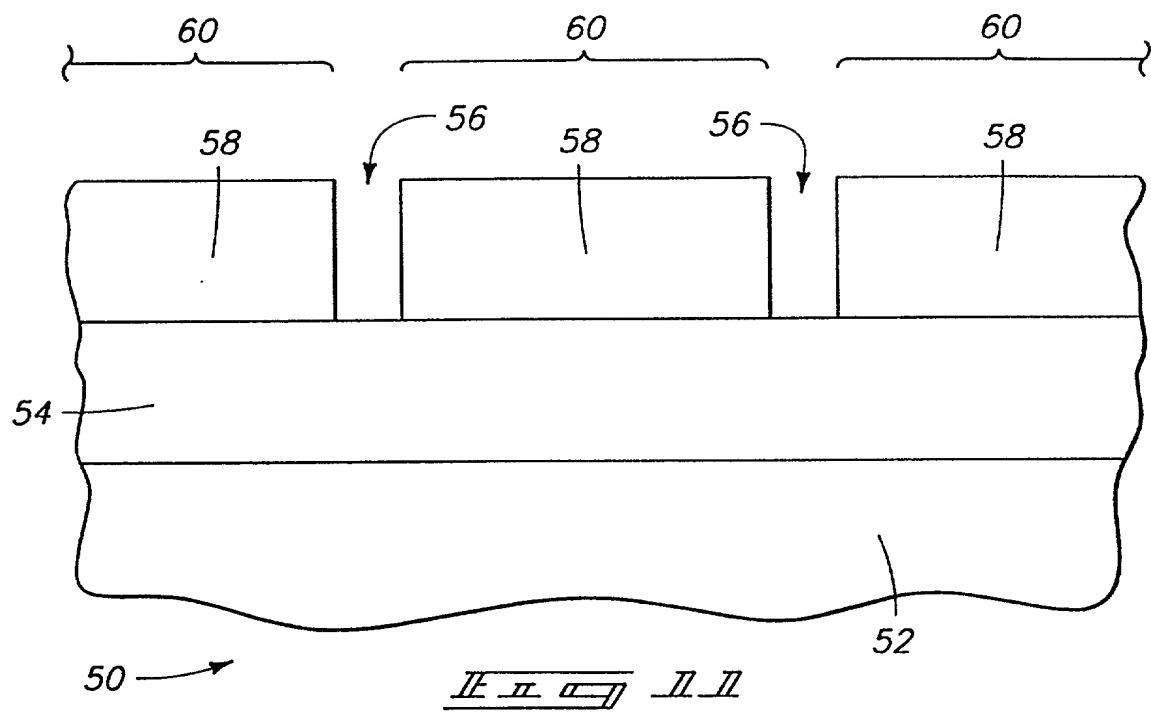
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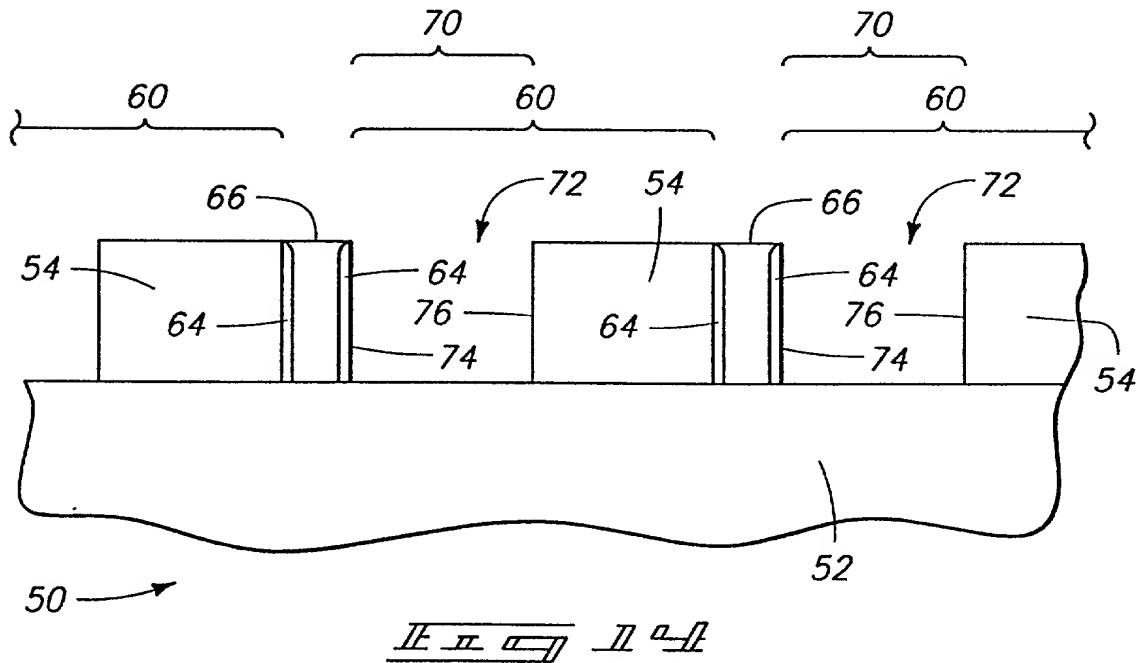
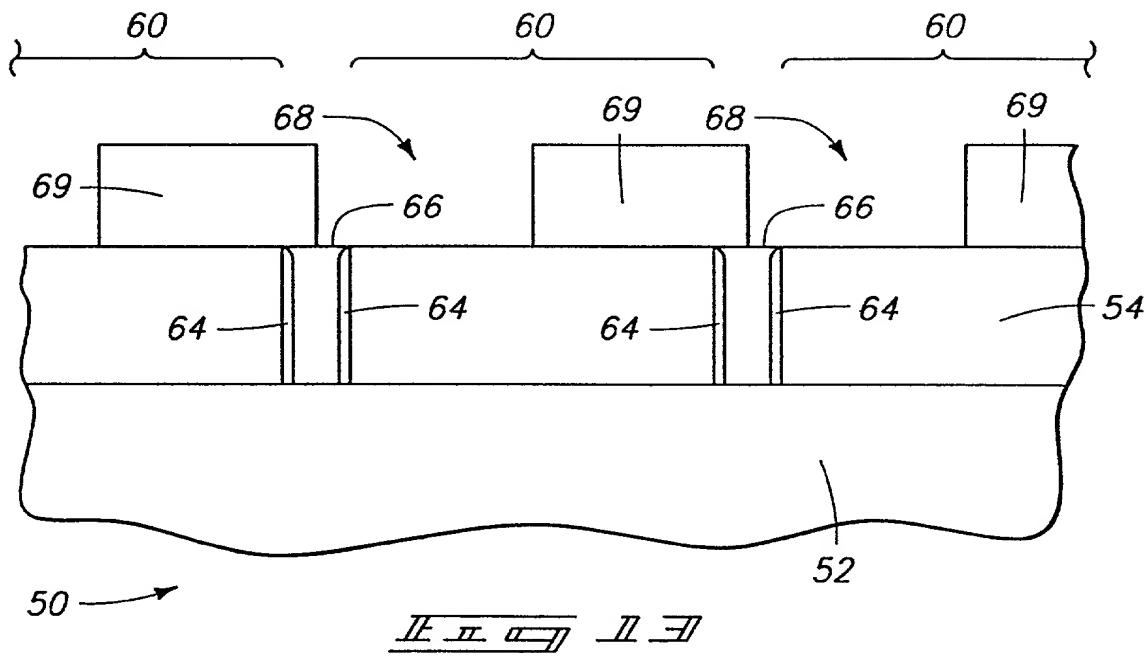
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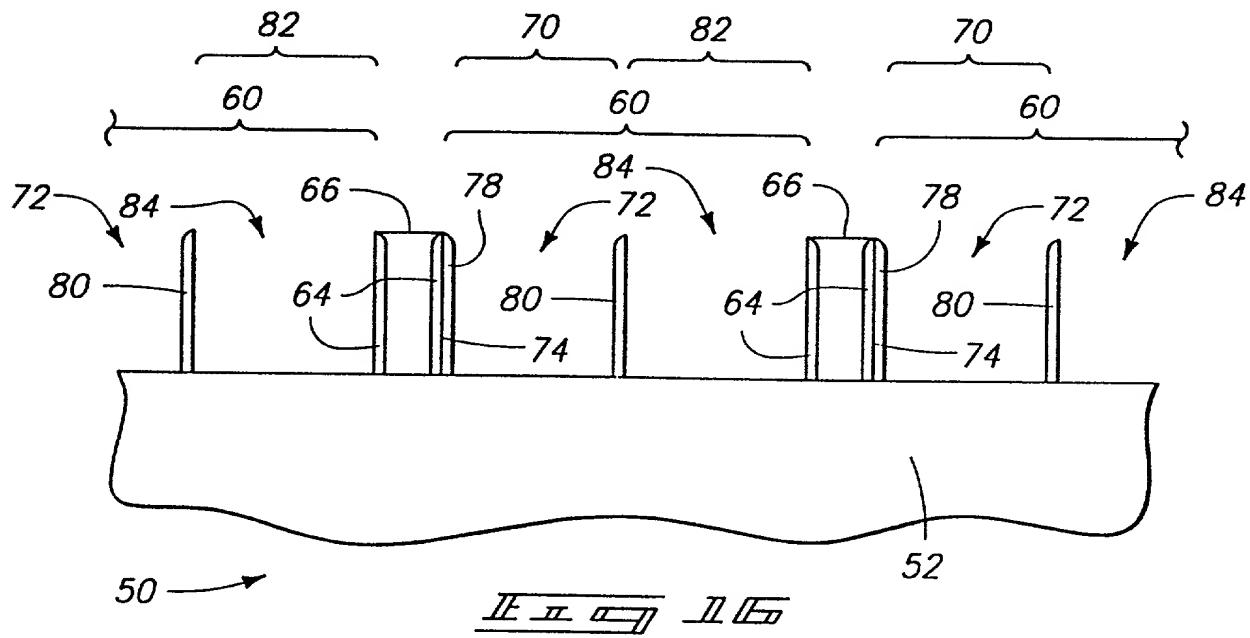
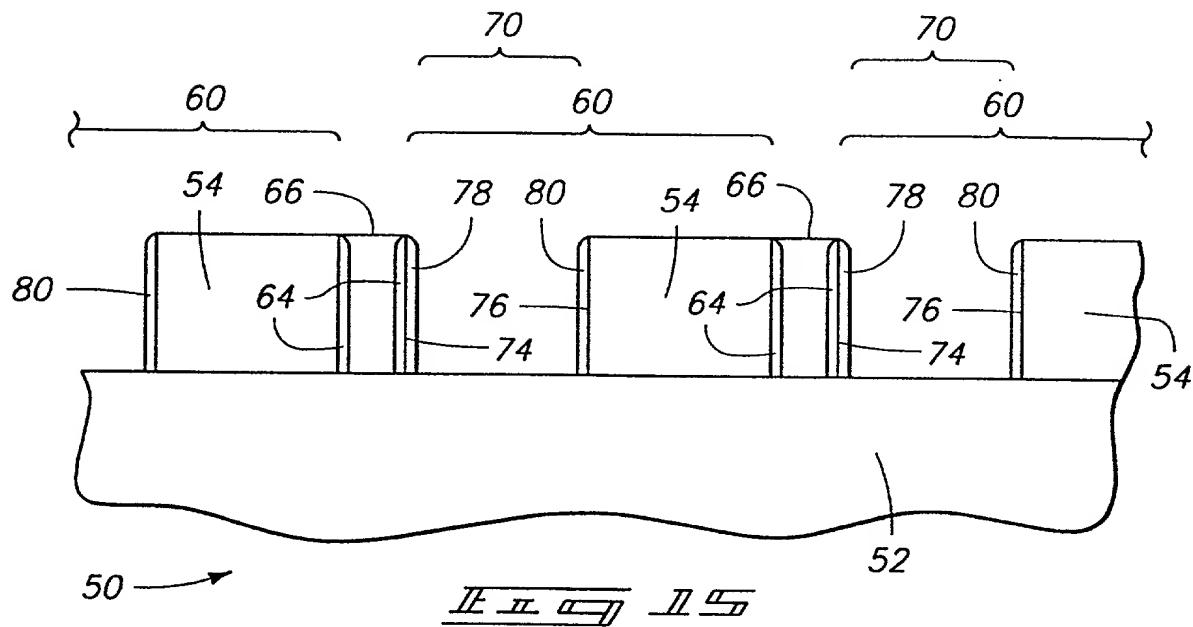
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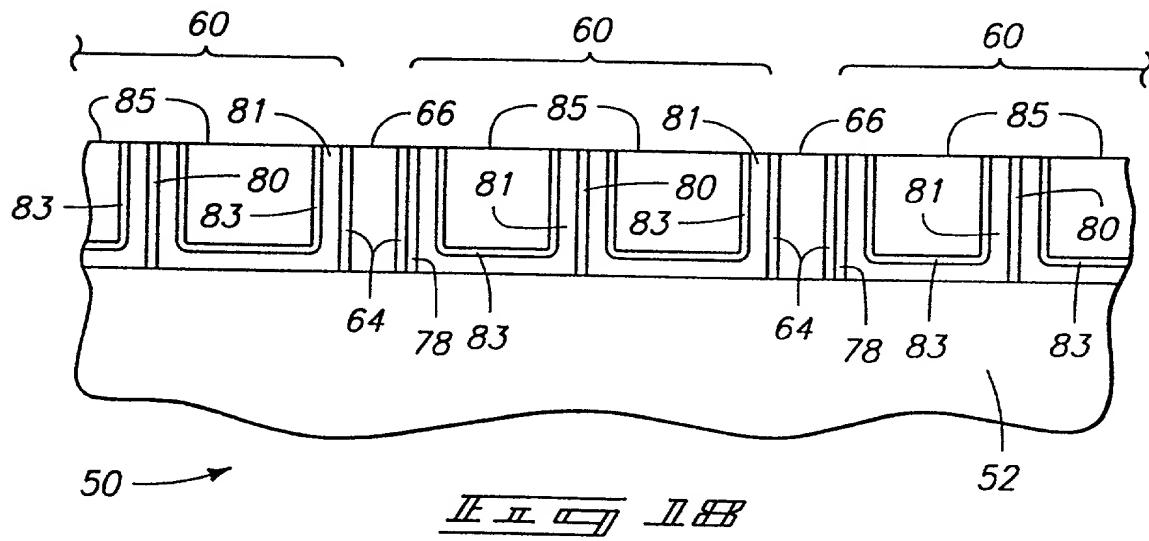
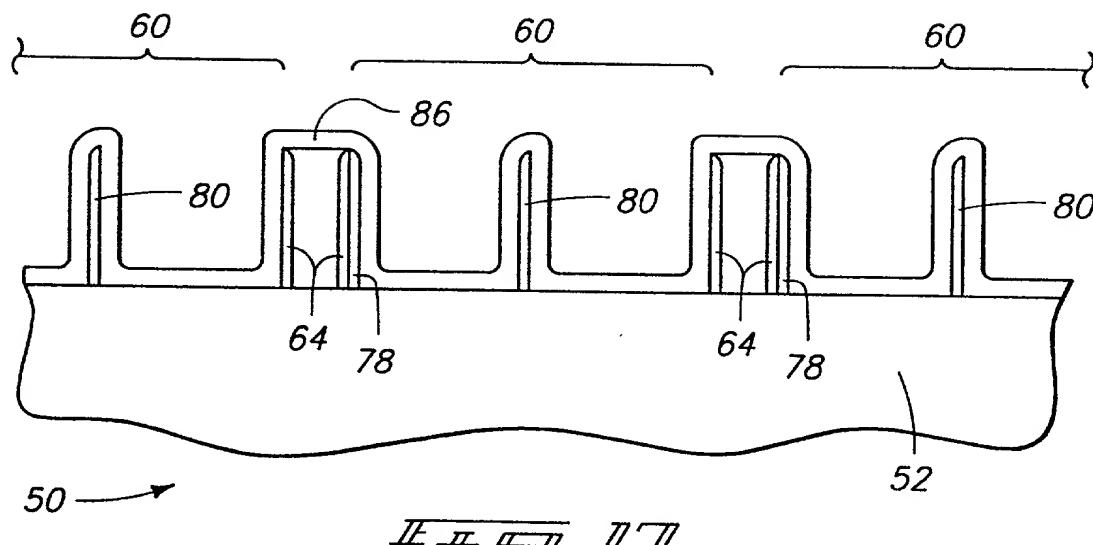
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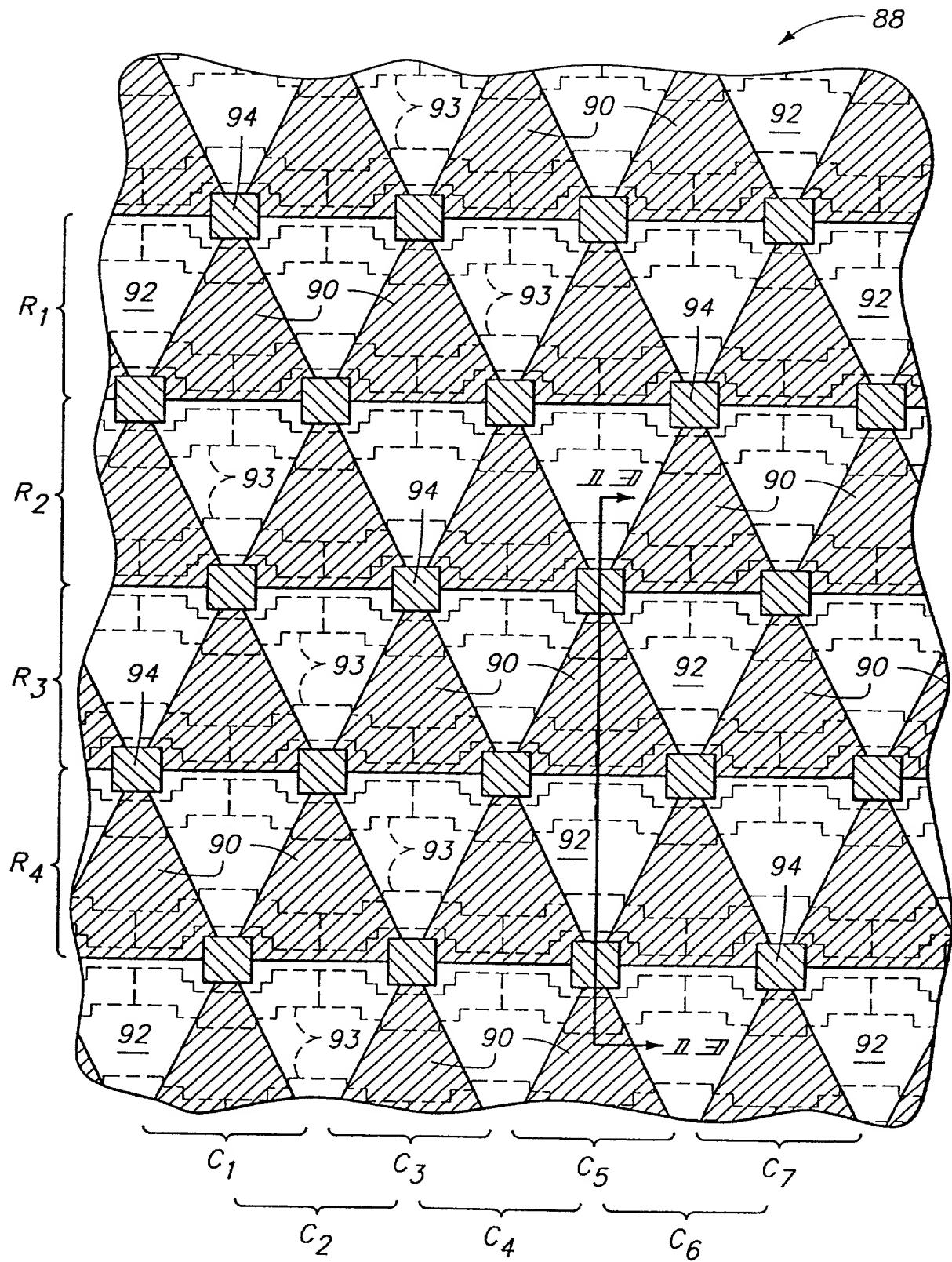
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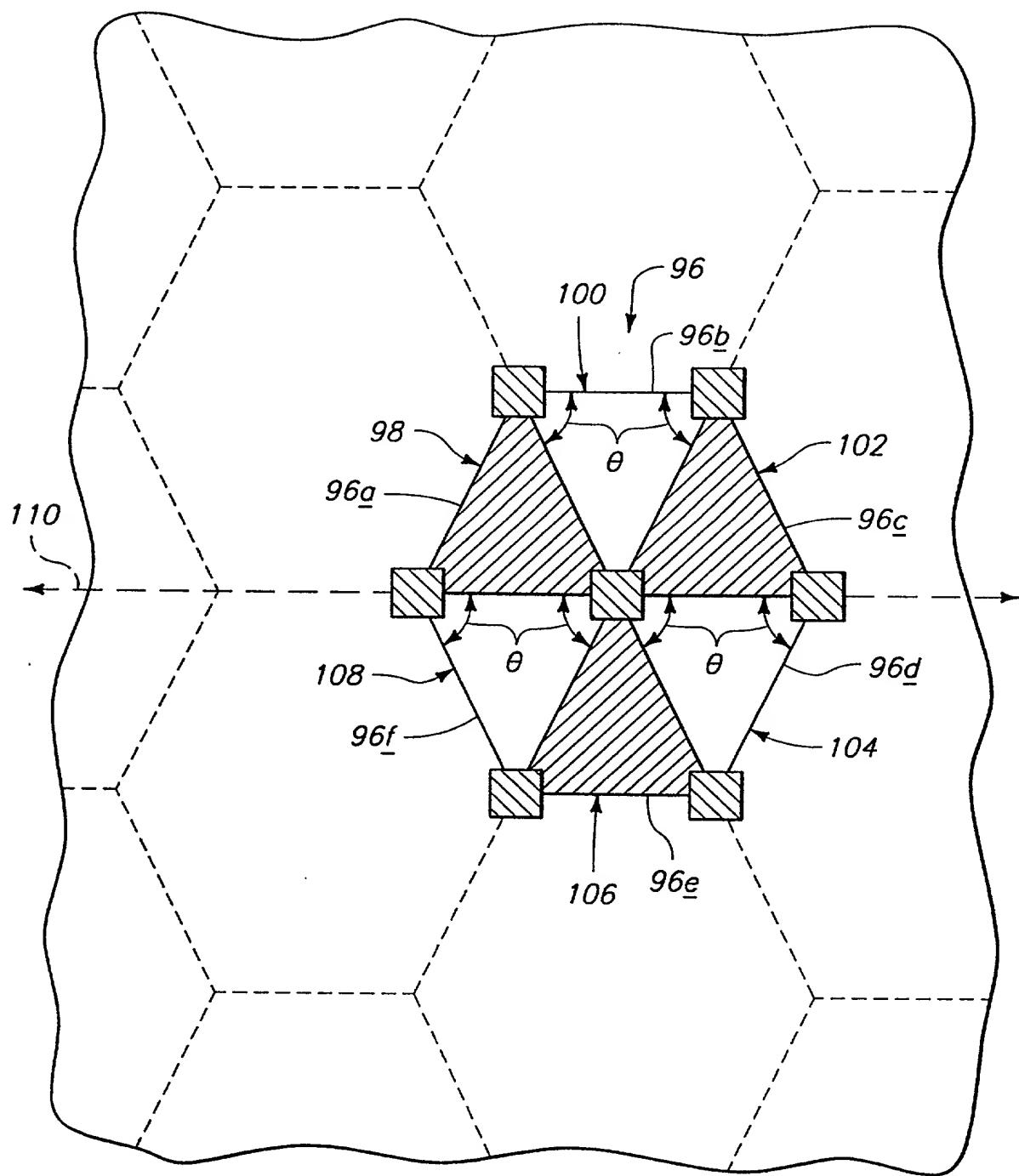
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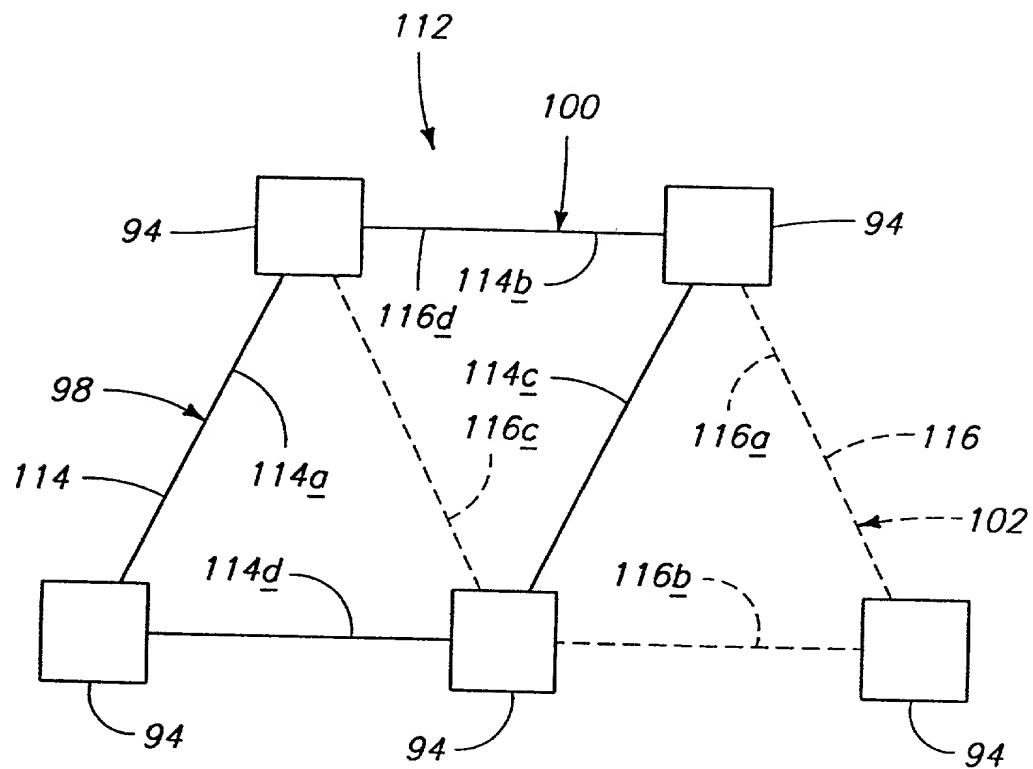
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1 **DECLARATION OF SOLE INVENTOR FOR PATENT APPLICATION**

2 As the below named inventor, I hereby declare that:

3 My residence, post office address and citizenship are as stated
4 below next to my name.

5 I believe I am the original, first and sole inventor of the subject
6 matter which is claimed and for which a patent is sought on the
7 invention entitled: Semiconductor Processing Methods of Forming
8 Devices on a Substrate, Forming Device Arrays on a Substrate, Forming
9 Conductive Lines on a Substrate, and Forming Capacitor Arrays on a
10 Substrate, and Integrated Circuitry, the specification of which is attached
11 hereto.

12 I hereby state that I have reviewed and understand the contents
13 of the above-identified specification, including the claims.

14 I acknowledge the duty to disclose information known to me to
15 be material to patentability as defined in Title 37, Code of Federal
16 Regulations §1.56.

17 **PRIOR FOREIGN APPLICATIONS:**

18 I hereby state that no applications for foreign patents or inventor's
19 certificates have been filed prior to the date of execution of this
20 declaration.

21

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23

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EM156306369

1 **POWER OF ATTORNEY:**

2 As a named Inventor, I hereby appoint the following attorneys and
3 agent to prosecute this application and transact all business in the
4 Patent and Trademark Office connected therewith: Richard J. St. John,
5 Reg. No. 19,363; David P. Roberts, Reg. No. 23,032; Randy A. Gregory,
6 Reg. No. 30,386; Mark S. Matkin, Reg. No. 32,268; James L. Price, Reg.
7 No. 27,376; Deepak Malhotra, Reg. No. 33,560; Mark W. Hendrickson,
8 Reg. No. 32,356; David G. Latwesen, Reg. No. 38,533; George G.
9 Grigel, Reg. No. 31,166; Keith D. Grzelak, Reg. No. 37,144; John S.
10 Reid, Reg. No. 36,369; Lance R. Sadler, Reg. No. 38,605; James D.
11 Shaurette, Reg. No. 39,833; W. Bryan Farney, Reg. No. 32,651; Lia M.
12 Pappas, Reg. No. 34,095; and Michael L. Lynch, Reg. No. 30,871.

13 Send correspondence to: WELLS, ST. JOHN, ROBERTS,
14 GREGORY & MATKIN P.S., 601 W. First Avenue, Suite 1300, Spokane,
15 WA 99204-0317. Direct telephone calls to: Lance R. Sadler
16 (509) 624-4276.

17 I hereby declare that all statements made herein of my own
18 knowledge are true and that all statements made on information and
19 belief are believed to be true; and further that these statements were
20 made with the knowledge that willful false statements and the like so
21 made are punishable by fine or imprisonment, or both, under

22

23

24

1 Section 1001 of Title 18 of the United States Code and that such willful
2 false statement may jeopardize the validity of the application or any
3 patent issued therefrom.

* * * * * * * * *

Full name of sole inventor: Werner Juengling

Inventor's Signature: Wm. Jennings

Date: 23-CC7-96

Residence: **Boise, Idaho**

Citizenship: Austria / Europe

Post Office Address: 5660 S. Tecoma Place
Boise, ID 83705